

AMBIGUOUS TILT AND TRANSLATION MOTION CUES AFTER SPACE FLIGHT AND OTOLITH ASSESSMENT DURING POST-FLIGHT RE-ADAPTATION

S. J. Wood,^{1,2} A. H. Clarke,³ D. L. Harm,² A. H. Rupert,⁴ and G. R. Clément⁵

¹ Universities Space Research Association, Houston TX, ² NASA Johnson Space Center, Houston TX,

³ Charite Medical School, Berlin, Germany ⁴ U.S. Army Aeromedical Research Laboratory,
Fort Rucker AL, and ⁵ CNRS, Toulouse France

INTRODUCTION

Adaptive changes during space flight in how the brain integrates vestibular cues with other sensory information can lead to impaired movement coordination, vertigo, spatial disorientation and perceptual illusions following G-transitions. These studies are designed to examine both the physiological basis and operational implications for disorientation and tilt-translation disturbances following short duration space flights.

SPECIFIC AIMS

Ambiguous Tilt and Translation Motion Cues after Space Flight (Clément, Wood, Harm, Rupert):

This experiment utilizes a unique motion paradigm on NASA's Tilt-Translation Sled (TTS) in which the resultant gravito-inertial vector remains aligned with the body longitudinal axis during tilt motion (referred to as the Z-axis gravito-inertial or ZAG paradigm). One specific aim is to examine the effects of stimulus frequency on adaptive changes in eye movements and motion perception during independent tilt and translation motion profiles. The TTS provides pitch tilt combined with fore-aft translation. The variable radius centrifuge (VRC) provides lateral translation during rotation, resulting in illusory roll-tilt. We hypothesize that the greatest adaptive changes will occur in the mid-frequency range where there is a crossover of tilt and translation otolith-mediated responses. Another specific aim is to employ a closed-loop nulling task in which subjects are tasked to use a joystick to null out tilt motion disturbances on these two devices. The stimuli consist of random steps or sum-of-sines stimuli, including the ZAG profiles on the TTS. We hypothesize the ability to control tilt orientation will be compromised following space flight, with increased control errors corresponding to changes in self-motion perception. A final specific aim is to evaluate how sensory substitution aids (e.g., vibrotactile feedback) can be used to improve manual control performance. We hypothesize that performance on the closed-loop tilt control task will be improved with tactile display feedback of tilt orientation.

Otolith Assessment during Post-flight Re-adaptation (Clarke, Wood):

This experiment utilizes two experiment paradigms that allow unilateral assessment of otolith function. During unilateral centrifugation (constant rotation at 400 deg/s), subjects are displaced by 3.5 cm so that one utricle is located off-axis while the opposite side is centered over the axis of rotation. A second protocol utilizes the vestibular evoked myogenic potentials (VEMP) as an indicator of unilateral saccule function via vestibulo-collic pathways. One specific aim is to examine the variability (gain, asymmetry) in both otolith-ocular responses and the subjective visual vertical to unilateral centrifugation (UC), and measure the time course of post-flight recovery. Similarly, another aim is to assess the variability in amplitude and latency of VEMPs. This study design will allow test of hypotheses regarding changes in sensitivity to gravito-inertial acceleration, as well as the otolith asymmetry hypothesis - which is proposed by some authors (Egorov & Samarin, 1970; von Baumgarten et al., 1978; Markham & Diamond, 1996) as an explanation of individual variability in predisposition to motion sickness.

CURRENT STATUS AND PLANS

The current plans include testing on 8 short duration subjects (ZAG & Otolith) and 8 long duration subjects (Otolith only). Measurements will be obtained for each experiment pre-flight at L-120 (± 30), L-90 (± 30), and L-30, (± 10) days and post-flight at R+0, R+1, R+2 or 3, R+4 or 5, and R+8. The R+0 measures will utilize an integrated protocol on the variable radius centrifuge for subjects participating in both experiments. During the past year, measures were obtained on 3 STS-126 crewmembers. The next opportunity will be one subject on STS-128.

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